

Acoustic study of the influence of climate change on the propagation of noise generated by industrial units in real-time: by an industrial zone in Algeria

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ABSTRACT

The industrial revolution in the field of gas and oil treatment that has known the Oran region-Algeria-has participated in the production and propagation of noise pollution and loud noises on the environment and around the places residential, for this, a multitude of noises are now part of our daily life. This contribution concerns the propagation of noise pollution in the industrial environment and the effects caused by atmospheric pollution which has a great influence on the phenomenon of planetary climate change and on meteorological parameters, the latter having a great influence on the propagation of noise. Our study is part of the objective of evaluating the noise levels emitted by gas installations in the industrial zone of Arzew-Oran, and of seeing the effects of the variation of meteorological parameters on the propagation of noise. To do this, we have adopted a precise in-situ methodology. Subsequently, for the processing of the measurement results, we opted for the COD-TYMPAN software in real-time as a calculation tool to interpret our results.

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1. INTRODUCTION

The industrial revolution has not only disrupted the economies of developed countries but also their environment. Noise pollutants have been unknown for 50 years ago, now they are part of our daily life, especially in residential areas near industrial areas highly polluted by noise. For this, the current world suffers a lot from industrial activities which generate atmospheric pollution and especially emissions of greenhouse gases, the latter mainly contributing to climate change.

Noise is the second environmental factor in terms of health damage (WHO) [1], its dangerousness depends on the nature of the source that generates it (transport, industry). Algerian industry is an essential segment of the country's economic development [2], but generates significant pollution of our environment by different types of pollution (atmospheric [3]-[6], solid [7]-[13], marine [13]-[17]. Among these types of pollution, noise pollution is quite rare in scientific circles.

Today, the concern about noise pollution is considerable importance, especially in industrial environment where there is a large amount of machinery and equipment [18]. Several research studies have been carried out to address the problem of noise in urban and industrial environments [17]-[30]. Recent studies have shown that noise from industrial sources is more annoying than transporting noise (at equivalent

noise levels) [31]. This is mainly due to the specific characteristics of the industrial noise source, which emits different noises with dangerous characteristics (tonal, impulsive) [32]-[34].

These noises therefore directly affect workers at industrial sites, and indirectly affect the residents in the vicinity of these sites. Its dangerousness depends on the one hand on its own characteristics (its intensity, its frequency, its acoustic pressure, its duration and especially its level of exposure). On the other hand, it depends on the environment in which the meteorological parameters propagate, which plays a very important role in the acoustic propagation of noise (the speed of noise increases with the increase in air temperature).

Actually, the concern about climate change is gaining considerable importance, especially in an industrial environment where there is a very high rate of pollution (atmospheric, marine or noise). The industrial zone of Arzew (Oran--Algeria) is worldwide ranked among the tops twenty industrial zones [35]-[36] in the field of processing and exploitation of a gas and oil. However, on the environmental level, the complexes in the industrial area of Arzew generate a lot of pollution (atmospheric, marine and noise).

In our study, we were interested in the effect of climate change and meteorological parameters (temperature, humidity, wind speed and direction) on the propagation of noise pollution generated by the complexes of the industrial area.

2. MATERIALS AND METHODS

2.1. Material used:

The sound level meter we used is an integrating sound level meter (CLASS 2/UMERICEST-107) type II. It includes a special amplifier; a microphone and a voltage divider, which allow reaching an attenuation of electric signals, for stay in the amplifier linearity, range (50 to 80 dB) whatever the sound level. The Attenuator function can also allow the display of an easy-to-read measurement. It also includes the weighted filter, in particular the weighting filter A (it is a detection and reading device), that contains another amplifier and rectifier. So that the signal displayed is proportional to the effective noise pressure.

The information captured in the field by the acquisition and allocation of data in real-time [37]-[39], each second is measured simultaneously, and they are centralized on a central unit. This allows us to order and analyze our overall system with all the noise levels in dB (A) [40].



Figure 1. The system of measurement and simulation used

This study focuses on the environmental impact in terms of climate change on the propagation of noise pollution generated by Arzew industrial units.

Noise is defined as a vibration that propagates through the air. It causes an auditory sensation, which can be pleasant or become unpleasant, even dangerous if its level is excessive. It is measured in decibels (dB) and is characterized by [36]-[38]:

- Sound intensity: above 60 decibels (dB), there is a risk for hearing;
- Low or high frequency: high noise is more dangerous than low frequency;
- Sound pressure, which quantifies the amplitude of a sound;
- Duration: the noise dose is proportional to the exposure time.

2.2. Method

- 1 – Input data
- 2 – Data processing and adjusting
- 3 – Using modelling
- 4 – Noise maps production

The Figure 2 presented the Data Acquisition System DAS.

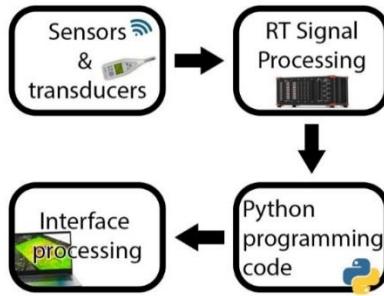


Figure 2. Block Diagram of a Data Acquisition System

2.3. Phenomena involved in acoustic propagation in an outdoor environment

We present the phenomena involved in linear acoustic propagation in an external environment. The determination of the sound pressure field depends on several parameters related to the characteristics of the propagation medium (atmosphere), to the boundary conditions (soil, diffraction), to the physical characteristics of the source as well as to the geometric configuration (position of the source and the receiver, land transport infrastructure) [40]-[41].

The relation of the pressure level L_p calculated by:

$$L_p = L_w - Attdiv - Attabs - Attdif - Attground - WeatherAt \quad (1)$$

Where:

The pressure level L_p calculated by considering the sum of the attenuations due to the geometric divergence $Attdiv$, the absorption of the atmosphere and the materials $Attabs$, the diffraction by the obstacles $Attdif$, the ground effect $Attground$ and attenuation due to meteorological effects $WeatherAt$, L_w is the sound power level of the sound source.

The relationship of the speed of sound defined by:

$$VS = \sqrt{\gamma \cdot R \cdot T} \text{ (m/s)} \quad (2)$$

Where:

γ : (Gamma) the adiabatic constant.

R : The molar gas constant [$J \cdot kg^{-1} \cdot K^{-1}$]

T : The absolute temperature K.

In standards condition: $R_{air} = 287 \text{ J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$ and $\gamma = 1.4$, So $VS = 20.04\sqrt{T}$

We notice that the speed of sound in the area and proportionally with the square root of the area temperature. The climate change causes a significant increase in ambient temperature and therefore affects the propagation of noise.

To see the effect of the temperature increases on the propagation of noise generated by Arzew's industrial units, we opted for the following approach:

A series of measurements made at the noise sources (inside the GP1/Z, GNL1Z and GNL2 complexes).

We set out to map the noise of the study area using the **COD-TYMPAN** simulation software,

Knowing that to see the effect of the increase in temperature we have each time varied the temperature between $T = 25^\circ\text{C}$, $T > 25^\circ\text{C}$, $T < 25^\circ\text{C}$.

The management of ambient noise has defined various global indicators, in particular [41]-[42]:

- Lday corresponds to the average noise level representative of a day (LAeq (7am-7pm)), determined over a year. It is an indicator of noise associated with annoyance during the daily period.
- Levening corresponds to the average noise level representative of an evening (LAeq (19h-23h)), determined over a year. It is an indicator of noise associated with annoyance in the evening.
- Lnight corresponds to the average annual noise level representative of a night (LAeq (11pm-7am)). He makes
- a noise indicator associated with sleep disturbances.

- The weighted indicator Lden (day-evening-night) represents the average annual level over 24 hours evaluated from the average levels of the day (7am-7pm), evening (7pm-11pm) and night (11pm-7am). In its calculation, the average evening and night levels increased by 5 and 10 dB (A) respectively.

In other words, this noise indicator is associated with the overall acoustic annoyance associated with long-term noise exposure and takes into account that noise experienced in the evening and at night experienced as more annoying. It used in particular for the establishment of strategic noise maps. It calculated according to the formula:

$$L_{DEN} = 10 \log \left(\frac{1}{24} \right) \left[12 * 10^{\frac{LAeq7-19}{10}} + 8 * 10^{\frac{LAeq23-7}{10}} + 4 * 10^{\frac{LAeq19-23}{10}} \right] \quad (3)$$

3. RESULTS AND DISCUSSION

In the first part of our work, we have carried out of noise measurements in real-time in order to evaluate the noise pollution in the industrial units GP1/Z, GNL1 and GNL2.

Tables 1, 2, 3 and 4 represent the noise levels recorded in real-time in the three complex zones GP1/Z, GNL1 and GNL2. Table 1 shows the turbocharger train noise levels recorded in the GP1/Z complex zone. Table 2 shows the compressors noise levels recorded in the complex zone GNL1. Table 3 shows the pic-train noise levels recorded in the complex zone GNL1. Table 4 shows the pic-train noise levels recorded in the complex zone GNL2.

Table 1. Noise levels recorded in the GP1/Z complex zone

Noise source	Noise level measured in dB (A)
Turbocharger train 100	95,0
Turbocharger train 200	94,5
Turbocharger train 300	95,0
Moto compressor train 600	91,0
Moto compressor train 700	90,0

Table 2. Noise levels recorded in the GNL1 complex zone

Noise source	Noise level measured in dB (A)
Compressor 1 Train 100	95 dB
Compressor 2 Train 200	95 dB
Compressor 3 Train 300	95 dB
Compressor 4 Train 400	95 dB
Compressor 5 Train 500	95 dB

Table 3. Noise levels recorded in the GNL1 complex zone

Noise source	Noise level measured in dB (A)
Pic Train 100	95 dB
Pic Train 200	95 dB
Pic Train 300	95 dB
Pic Train 400	95 dB
Pic Train 500	95 dB

Table 4. Noise levels recorded in the GNL2 complex zone

Noise source	Noise level measured in dB (A)
Pic Train 100	115 dB
Pic Train 200	95 dB
Pic Train 300	95 dB
Pic Train 400	95 dB

According to the results of noise recording in GP1/Z, GNL1 and GNL2 complex zone, we notice that the noise pollution in the three complexes is higher; Tables 1, 2, 3, and 4 represent the principal factors that cause noise pollution in the industrial area are rotors of machines such as compressors and turbines.

The noise level results showed that the noise levels were between 95 and 115 dB (A). To determine the effect of variations in meteorological parameters on the propagation of noise, we studied two scenarios:

- In the first scenario: this involves setting the simulator on the ambient temperature T=25 °C;
- In the second scenario: it consists in varying the meteorological parameters in the following ways $T = 25 °C$, $T > 25 °C$, $T < 25 °C$, the effect of temperature on noise propagation.

In the second part of this work, we have evaluated noise pollution by noise mapping generated inside the industrial area of Arzew: GP1/Z, GNL1 and GNL2 complex zone.

3.1. Complex of GP1/Z

In figures 3, 4 and 5 below, we have represented the different simulation results found in the GP1/Z complex according to the two scenarios developed under the meteorological conditions; temperature variation $T>25 °C$, $T=25 °C$ or $T<25 °C$, with humidity = 70%, and wind speed = 20 km/h.

Figures 3 shows the mapping generated of the noise by the GP1/Z complex zone under meteorological conditions, temperature $T>25 °C$.

Figures 3, 4, and 5 represent the noise mapping generated by the impact of temperature variation on noise propagation in GP1/Z complex. The red dots represent the sources of noise where its value is great. More we will move away from noise sources, more noise pollution dissipate.

Figures 4 shows the mapping generated of the noise by the GP1/Z complex zone under meteorological conditions, temperature $T=25^{\circ}\text{C}$. Figures 5 shows the mapping generated of the noise by the GP1/Z complex zone under meteorological conditions, temperature $T<25^{\circ}\text{C}$.

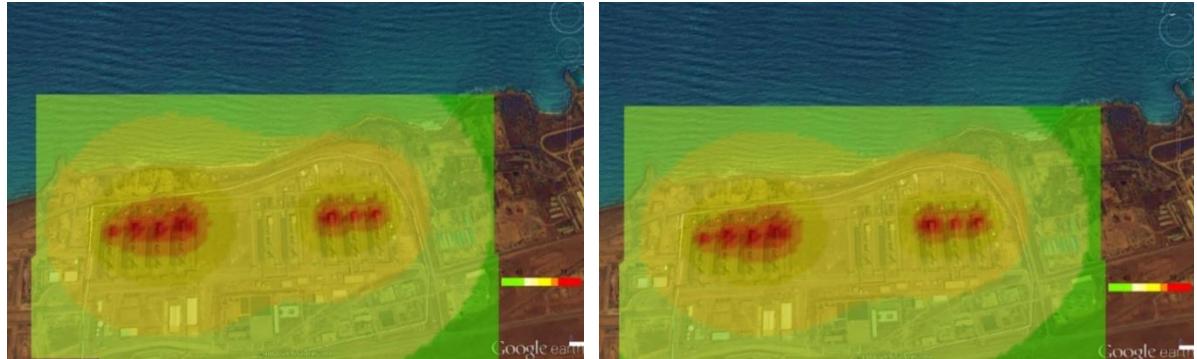


Figure 3. Noise mapping generated by the GP1/Z complex under meteorological conditions ($T>25^{\circ}\text{C}$)

Figure 4. Noise mapping generated by the GP1/Z complex under meteorological conditions ($T= 25^{\circ}\text{C}$)



Figure 5. Noise mapping generated by the GP1/Z complex under meteorological conditions ($T<25^{\circ}\text{C}$)

3.2. Complexes of GNL1 and GNL2

The Figures 6, 7 and 8 below, represent noise mapping generated for the two complex zone factories GNL1 and GNL2 under the meteorological conditions; temperature variation $T>25^{\circ}\text{C}$, $T=25^{\circ}\text{C}$ or $T<25^{\circ}\text{C}$, with humidity = 70%, and wind speed = 19 km/h.

Figures 6 shows the mapping generated of the noise by the GNL1 and GNL2 complex zone under meteorological conditions, temperature $T>25^{\circ}\text{C}$. Figures 7 shows the mapping generated of the noise by the GNL1 and GNL2 complex zone under meteorological conditions, temperature $T>25^{\circ}\text{C}$. Figures 8 shows the mapping generated of the noise by the GNL1 and GNL2 complex zone under meteorological conditions, temperature $T<25^{\circ}\text{C}$.

Figures 6, 7, and 8 represent the noise mapping generated by the impact of meteorological conditions on noise propagation in GNL1 and GNL2 complexes zone. The red dots represent the sources of noise where its value is great. More we will move away from noise sources, more noise pollution dissipate.

Figures 3-8 above represent a noise map on the two complex zones GP1 / Z, GNL1 and GNL2. It is remarkable that the places where the turbines and compressors are installed are the noisiest; but as one moves away from the center of the noisy space, the noise gradually slows down.

According to the simulation results found, it can be seen that meteorological parameters play a very important role in the phenomenon of acoustic propagation of noise pollution. When the parameters change, we see that the noise propagation surface increases and can reach the residential areas next to the industrial zone of Arzew.

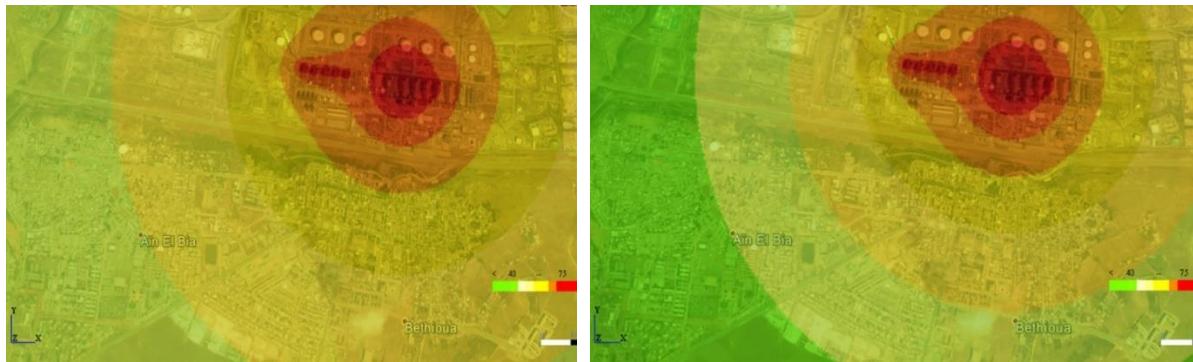


Figure 6. Noise mapping generated by the GNL1 and GNL2 complexes under meteorological conditions ($T > 25^{\circ}\text{C}$)

Figure 7. Noise mapping generated by the GNL1 and GNL2 complexes under meteorological conditions ($T = 25^{\circ}\text{C}$)

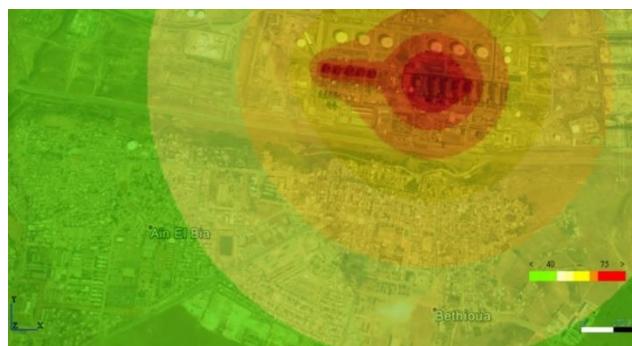


Figure 8. Noise mapping generated by the GNL1 and GNL2 complexes under meteorological conditions ($T < 25^{\circ}\text{C}$)

4. CONCLUSION

From the work we have done, we can see that: a) The propagation of noise is directly linked to the modification of meteorological parameters due to the phenomenon of climate change such as: temperature; or we have observed a wide diffusion that when the temperature is above 25°C , this diffusion can cause a health risk on the one hand for the workers of these complexes and on the other hand for the neighboring residential areas (Ain-El Bia and Bethioua). We observed subsequently that the noise propagation is reduced when the temperature is lower than 25°C , which confirms the hypothesis explained. b) The recorded noise levels are higher in the three complexes (plant) GNL1, GNL2, and GP1/Z, whose noise limit is 70 dB recommended by Algerian regulations. c) The analysis of the noise mapping allowed us to improve the study of noise in the Arzew area by obtaining robust results on noise pollution.

Finally, from the results we obtained, we show that our operator includes two steps, data monitoring, and processing of this data in real-time. This concept implemented through programming and gateways adapting to this study. The efficiency of this system is much more cost-effective as it will also reduce measurement errors and allow us to analyze the data collected on-site in real-time.

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